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DOI: <https://doi.org/10.1016/j.jenvp.2021.101684>

Posted at the Zurich Open Repository and Archive, University of Zurich

ZORA URL: <https://doi.org/10.5167/uzh-206683>

Journal Article

Published Version

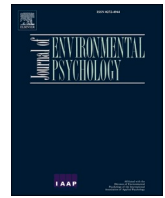


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Originally published at:

Hopwood, Christopher J; Schwaba, Ted; Bleidorn, Wiebke (2021). Personality changes associated with increasing environmental concerns. *Journal of Environmental Psychology*, 77:101684.

DOI: <https://doi.org/10.1016/j.jenvp.2021.101684>



# Personality changes associated with increasing environmental concerns

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## ARTICLE INFO

Handling Editor: Sander van der Linden

### Keywords:

Sustainability  
Environment  
Climate change  
Personality traits  
Personality development

## ABSTRACT

Using data from 58,748 participants from a nationally representative German sample, we tested preregistered hypotheses about factors that impact concerns about the environment over time. We found that environmental concerns increased modestly from 2009 to 2017. Individuals in middle adulthood tended to be more concerned and showed more consistent increases in concern over time than younger or older people. Consistent with previous research, personality traits were correlated with environmental concerns. We present novel evidence that increases in concern were related to increases in the personality traits neuroticism, openness to experience, and potentially agreeableness. These findings highlight the importance of understanding individual level factors associated with changes in environmental concerns over time, towards the promotion of more sustainable behavior.

Sustainable behavior is a primary tool for promoting environmental health (Chuang et al., 2020; Osbaldiston & Schott, 2012), but it requires changes in habits and norms that are often uncomfortable, inconvenient, and costly (Aragon-Correa et al., 2020; Hall et al., 2018; Weber, 2015). Key to promoting sustainable behavior is thus a better understanding of the factors that motivate individual action. Many types of sustainable behavior reflect personal decisions and sacrifices, such as taking the time to recycle, using less convenient modes of transportation, foregoing certain goods, or paying more money. Because people differ in their willingness to make such decisions and sacrifices, considerable potential lies in a greater understanding of the personal factors that promote or impede sustainable behaviors (Freeman et al., 2020; Hirsch, 2010; Soutter et al., 2020).

One critical factor is *personal concern*. People are more motivated to change their behavior when they are concerned that their behavior has negative consequences (Hennecke et al., 2014; Liberman & Trope, 1998). It follows that increases in concerns about the environment promote more sustainable behavior (Fig. 1; Barnett et al., 2019; Binder & Blankenberg, 2016; Jekria & Daud, 2016; West et al., 2018). But what heightens concern about the environment? There is mounting empirical evidence that people with certain personalities are more likely to be concerned about the environment (Hirsch, 2010; Milfont & Sibley, 2012; Weber, 2010) and engage in sustainable behavior (Soutter et al., 2020). In a previous cross-sectional study, Hirsch (2010) found positive associations with four personality traits: neuroticism, openness,

agreeableness, and conscientiousness.

Notably, existing studies on personality traits and environmental concerns have relied on cross-sectional designs to delineate personality-concern associations. There is an essential difference between how people are different from one another at one point in time, and how they experience lasting changes via interactions with the world around them as their lives progress. Moreover, cross-sectional effects are prone to influences of third variables that are less likely to affect longitudinal associations. An examination of links between changes in personality and changes in environmental concerns over time thus deepens our understanding of the psychological processes associated with environmental concerns, and could provide key insights about pathways to motivate sustainable behavior.

It is established that personality traits change over time (Roberts et al., 2006), some people change more than others (Schwaba & Bleidorn, 2018), and that variation in personality changes depends in part on certain experiences (Bleidorn et al., 2018; Luo et al., 2017), including large-scale social-environmental changes. We thus predicted dynamic links between changes in environmental concerns and changes in personality. We expected that changes in the traits that have been associated with concerns about the environment in cross-sectional studies (Hirsch, 2010; Soutter et al., 2020) – neuroticism, conscientiousness, agreeableness, and openness – would be positively associated with changes in environment concerns.

In summary, the goal of this pre-registered study was to examine the

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<https://doi.org/10.1016/j.jenvp.2021.101684>

Received 12 November 2020; Received in revised form 8 September 2021; Accepted 9 September 2021

Available online 13 September 2021

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co-development of personality traits and environmental concerns. We used longitudinal data from a German representative sample whose concerns about the environment and climate change were assessed biannually from 2009 to 2017, and whose personality traits were assessed three times during that span. We tested whether people have become increasingly more concerned about environmental issues over the past decade, and whether people who experienced the most pronounced increases showed corresponding changes in personality traits.

## 1. Materials and methods

The preregistration for this study can be found at <https://osf.io/fhqlja/>. We used data from the German Socioeconomic Panel (GSOEP; Wagner et al., 2007; N = 58,748). The sample was 53% female and the average age was 48.06 years (SD = 17.35).

Concern for the environment and concern for climate change were measured annually with single items, rated on a 3-point scale ranging from “not concerned at all” to “very concerned”. The personality traits extraversion, agreeableness, conscientiousness, neuroticism, and openness were measured in 2009, 2013, and 2017 with the 15-item version of the Big Five Inventory-S (Gerlitz & Schupp, 2005). Coefficient alphas ranged from 0.48 to 0.67; omega total values ranged from 0.55 to 0.70 (Table S1). This abbreviated measure has demonstrated measurement invariance across age groups (Brandt et al., 2020) and measurement occasions (Specht et al., 2011).

Socioeconomic status (SES) was computed at each participant's first measurement wave using the International Socio-Economic Index of occupational status (ISEI), using data on occupation, parental education, and income (Ganzeboom et al., 1992). Cohorts were defined by decade. Age cohort sample sizes were as follows: 270 were born in the 1910s or earlier, 1920s (1,712), 1930s (4,427), 1940s (5,655), 1950s (7,892), 1960s (11,884), 1970s (11,339), 1980s (9,552), 1990s or later (6,017). Education was computed as the maximum educational attainment across all measurement occasions provided by a participant; the average participant completed upper secondary education (see Tables S2 and S3).

Analyses were conducted in R (R core team, 2015), with structural equation models estimated using lavaan (Rosseel, 2012) and visualized using ggplot2 (Wickham, 2016). Using Full Information Maximum Likelihood estimation to handle missing data, we fit linear univariate latent growth curve models to characterize change in both environmental concern variables (9 waves of data) and all five personality traits (3 waves of data; Fig. S1). These models fit the data well (RMSEAs  $\leq$  0.046, CFIs  $\geq$  0.971). We then fit bivariate latent growth curve models to examine correlates between latent slope and intercept factors (Tables S4 and S5). These models again fit the data well (RMSEAs  $\leq$  0.046, CFIs  $\geq$  0.971). Finally, we added time-invariant covariates of age at study entry, SES, sex, and highest level of education achieved during the study period to examine the persistence of hypothesized effects with these variables controlled (Table S6, Fig. S2).

## 2. Results

The average person in our sample reported being slightly more than “somewhat concerned” about both climate change and the environment. On average, these concerns increased slightly from 2009 to 2017 (Fig. 1; Cohen's  $d$  between 2009 and 2017  $\sim$  0.10). Univariate growth curve models fit the data well and confirmed significant but modest increases for both concern about the environment ( $b = 0.002$  per year,  $p < .001$ , 95% CI [0.001,.003]) and concern about climate change ( $b = 0.007$  per year,  $p < .001$ , 95% CI [0.006,.008]).

However, we also found that these relatively flat trajectories masked underlying variability as a function of age, both within individuals and between cohorts. Fig. 2 depicts concerns across different ages, both for the entire sample at the 2009 assessment and for individual cohorts across all assessment waves. Individuals in middle to late adulthood

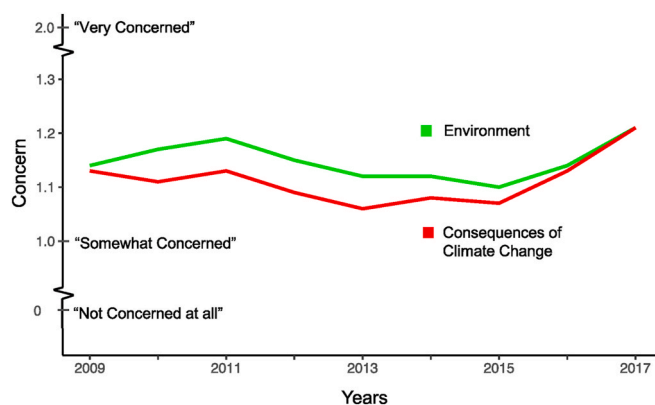


Fig. 1. Average environmental concerns in a German representative sample from 2009 to 2017 (N = 58,748 participants, 310,743 assessments).

expressed the most concerns about both environmental issues and climate change, whereas younger and older individuals were relatively less concerned. Moreover, cohorts born between 1940 and 1990 experienced relatively sharp increases across assessment waves, whereas those born before 1940 or after 1990 showed decreases in concern over time. Thus, relatively modest increases in concern about the environment at the aggregate level were masked by systematic patterns across age cohorts and stronger increases as a function of age within age cohorts.

Over the course of the study period, we found significant increases in extraversion ( $B = 0.004$  per year,  $p < .001$ , 95% CI [0.003,.006]) and openness ( $B = 0.011$  per year,  $p < .001$ , 95% CI [0.010,.012]) and decreases in conscientiousness ( $B = -0.009$  per year,  $p < .001$ , 95% CI [-0.010, -0.007]) and neuroticism ( $B = -0.009$  per year,  $p < .001$ , 95% CI [-0.011, -0.009]). Mean levels of agreeableness remained stable ( $B = 0.001$  per year,  $p = .059$ , 95% CI [-0.000,.003]). We also found significant ( $p < .001$ ) individual differences in change across all study variables ( $b = 0.0015 - 0.0020$ ) enabling tests of longitudinal association between environmental concerns and personality.

Our primary goal was to test pre-registered hypotheses about the cross-sectional and longitudinal associations between personality traits and environmental concerns. Bivariate latent growth curve models that included the trajectories of both personality traits and environmental concerns fit the data well. We predicted cross-sectional and longitudinal associations between both environmental concern variables and higher agreeableness, conscientiousness, neuroticism, and openness. Intercept (i.e., cross-sectional) correlations were significant for all five personality traits, including the four that were hypothesized as well as higher extraversion (Table 1).

Changes in environmental concerns, however, were only significantly related to changes in two traits, neuroticism and openness, whereas changes in concerns about climate change were related to increases in neuroticism, openness, and agreeableness. These effects held when controlling for plausible third-variable effects of age, SES, sex, and education. Co-development between environmental concerns and openness declined in magnitude but remained strong ( $rs = 0.69$  and  $0.66$ ) when including these covariates. Overall, these effects indicate that nearly half of the variance in increases in environmental concerns over time were explained by increases in openness, and that changes in neuroticism and potentially agreeableness also play a meaningful role in concern about the environment.

There were also some unpredicted significant correlations in these models between intercepts and slopes. Specifically, people who were more concerned about the environment on average tended to become more neurotic, less agreeable, and less conscientious over time, whereas people who were more neurotic tended to become less concerned about the environment.

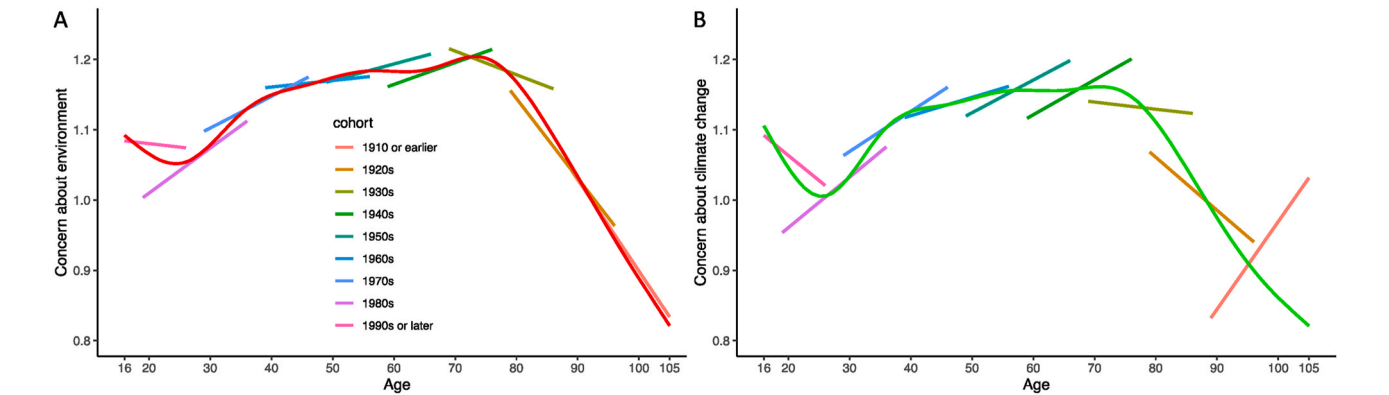


Fig. 2. Age trends in concern about the environment (A) and climate change (B) 2009–2017 (N = 58,748 participants, 310,743 assessments).

**Table 1**  
Co-development between personality traits and concerns about the environment and climate change.

Trait	Personality Parameter	Environmental Concern Parameter	Environment			Climate Change		
			<i>r</i>	<i>p</i>	95% CI	<i>r</i>	<i>p</i>	95% CI
Extraversion	Intercept	Intercept	.03	.001	[.01, .06]	.06	<.001	[.04, .08]
	Intercept	Slope	.04	.135	[-.01, .09]	.00	.963	[-.05, .05]
	Slope	Intercept	-.07	.101	[-.15, .01]	-.09	.020	[-.17, -.01]
	Slope	Slope	-.01	.920	[-.18, .16]	.12	.157	[-.05, .28]
Agreeableness	Intercept	Intercept	.16	<.001	[.14, .18]	.15	<.001	[.13, .18]
	Intercept	Slope	-.07	.011	[-.13, -.02]	-.08	.005	[-.13, -.02]
	Slope	Intercept	-.13	.001	[-.21, -.06]	-.16	<.001	[-.23, -.08]
	Slope	Slope	.14	.102	[-.03, .30]	.22	.006	[.06, .39]
Conscientiousness	Intercept	Intercept	.10	<.001	[.08, .12]	.13	<.001	[.11, .15]
	Intercept	Slope	-.07	.017	[-.13, -.01]	-.11	<.001	[-.17, -.06]
	Slope	Intercept	-.11	.002	[-.17, -.04]	-.11	.001	[-.18, -.05]
	Slope	Slope	.07	.319	[-.07, .22]	.15	.032	[.01, .29]
Neuroticism	Intercept	Intercept	.20	<.001	[.17, .22]	.18	<.001	[.16, .20]
	Intercept	Slope	-.10	<.001	[-.15, -.05]	-.12	<.001	[-.17, -.07]
	Slope	Intercept	-.13	<.001	[-.20, -.06]	-.10	.004	[-.16, -.03]
	Slope	Slope	.45	<.001	[.30, .60]	.41	<.001	[.26, .56]
Openness	Intercept	Intercept	.23	<.001	[.21, .25]	.21	<.001	[.19, .23]
	Intercept	Slope	-.03	.215	[-.09, .02]	-.04	.114	[-.09, .01]
	Slope	Intercept	-.10	.047	[-.20, .00]	-.09	.064	[-.19, .01]
	Slope	Slope	.88	<.001	[.54, 1.00]	.83	<.001	[.51, 1.00]

Note. Bold font indicates significance ( $p < .01$ ).

3. Discussion

Personal concern is a potent motivator for individual action, and individual action is a powerful tool in the fight against climate change. We found that participants from a large representative German sample are significantly concerned about climate change and the environment, that these concerns increased over the past decade, and that these increases were sharper for some people than for others. People’s age, cohort, and personality traits all helped explain these differences; the single largest preregistered effect indicated that as people become more open to experience, they also become more concerned about the environment.

Interpretations of the trajectory of environmental concerns over time are complicated by the distinct impacts of the general passage of time, individual aging processes, and generational cohort effects. There were modest increases in environmental concerns over time, on average. However, individuals between the ages of 40 and 80 had higher levels of concern than individuals on either the younger or older tails of the age distribution (Fig. 2). This pattern corresponds to the results reported in a study of changes in environmental concern across 33 countries over a similar period of time (Franzen & Vogle, 2013). Moreover, whereas individuals in these middle cohorts tended to experience increasing levels of concern from 2009 to 2017, younger and older age groups exhibited a mix of trajectories, including decreases in some age groups

(Fig. 2).

This study replicated previous cross-sectional studies indicating that personality traits are robust predictors of environmental concern (Hirsch, 2010), as well as other sustainability-related attitudes and behaviors (Milfont & Sibley, 2012; Soutter et al., 2020). Findings from this study suggest that personality might represent an avenue for personalizing sustainability interventions based on individual concerns and values (Anagnostopoulou et al., 2018). For example, conscientious people might be most driven to engage in sustainable behavior by their sense of responsibility, agreeable people by their desire to do good for others, and neurotic people by their anxieties about future threat.

Importantly, our results provide new evidence that changes in personality traits track with changes in environmental attitudes and behaviors. Increases in openness explained approximately half the variance in increases in environmental concerns, even with demographic factors controlled. Individuals who are more open to experience tend to be interested in aspects of the environment outside of themselves, positively disposed to progressive values and causes, and oriented towards future possibilities (McCrae & Sutin, 2009). As people become more open over time, they may become more aware of the impacts of climate change, more likely to consider a future world impacted by climate change, and thus more concerned. As such, promoting openness may be a potent pathway for fostering sustainable behavior. Conversely, increasing levels of concern may lead to greater

consideration of new possibilities about where to live or how to change behavior to be more sustainable. Thus, increasing concerns about climate change could provoke a more serious reflection about how to effectively respond, as indicated by greater openness.

We also found that people who became more neurotic and potentially agreeable over time showed corresponding increases in environmental concerns. Neuroticism involves a tendency to experience negative emotions such as anxiety, depression, and anger, all of which are understandable consequences of awareness of the climate crisis. These findings suggest that rising concerns about the environment are associated with increasingly unpleasant emotions. As neuroticism is a strong predictor of psychopathology (Lahey, 2009), our findings further suggest a possible connection between environmental issues and mental health (Berry et al., 2010). At a more normative level, sub-clinical anxiety may promote behavior change, and thus individual increases in neuroticism, for example via information about the threat posed by climate change, may be one avenue towards more sustainable behavior.

Agreeableness was a significant and predicted co-developmental correlate of concerns about climate change but, in contrast to our predictions, it was not significantly associated with concerns about the environment. Agreeable people tend to be friendly, empathic, and kind. People who become more agreeable may concurrently become more sympathetic to the suffering people will endure as a consequence of climate change, and thereby experience increasing concerns about climate change. In contrast to our predictions, we did not observe longitudinal associations between environmental concerns and conscientiousness. This finding may suggest that, while people who tend to be more conscientious also tend to be more concerned about the environment, perhaps because of shared associations with other variables (such as neuroticism and agreeableness; Digman, 1997), the relationship is not specific insofar as between-person differences in within-person increases in conscientiousness are not associated with relative increases in environmental concern over time.

There were some unpredicted intercept-slope correlations of potential interest. For example, we found that people with greater environmental concerns at baseline became more neurotic over time. This may suggest that, as the climate situation worsens, it increases negative affects among people who are particularly concerned about the environment. However, we note that intercept-slope correlations can be challenging to interpret because of issues such as regression to the mean.

Findings of longitudinal associations between environmental concerns and personality traits raise questions about causality. If changes in personality cause changes in concern, and ultimately behavior, personality interventions could help promote sustainable behavior and other prosocial outcomes (Hudson & Fraley, 2015; Stieger et al., 2018), particularly when connected to tractable, practical models of sustainability (Clark et al., 2016). It is also possible that changes in concern about the environment cause changes in personality. This finding would provide important information about the factors that impact personality development (Roberts et al., 2017), an issue with important implications for a variety of public policy issues (Bleidorn et al., 2019).

Most observed study effects were small, suggesting a weak association between personality and environmental concern. That being said, this study was limited by the use of very brief measures that have fairly low reliabilities. Statistical power was further limited by the relatively short study duration and the availability of only three assessment waves (Hertzog et al., 2006; Rast & Hofer, 2014). Taken together, these issues may have limited our ability to detect significant slope correlations. Future research with more reliable measures, more assessment waves, briefer assessment intervals, and longer study durations are needed. We also note that results may vary across time or cultures (Hopwood et al., 2021). Further research on the co-development of personality traits and environmental concerns is needed in different kinds of samples. The accumulation of such studies will enable tests of the effect of time or era on associations between personality and environmental concerns. Finally, it would be helpful to measure sustainability-related attitudes

and behaviors beyond concerns, to provide a fuller picture of how personality is related to environmental issues.

#### 4. Conclusion

Concerns about the environment have been increasing somewhat in the German population over the last decade, but this general trend masks larger increases within age cohorts, particularly among middle-aged adults. We replicated the finding that concerns about climate change are consistently related to a range of personality traits, and presented novel evidence that increases in the personality traits openness, neuroticism, and potentially agreeableness are associated with increases in environmental concerns, even with age, education, sex, and SES controlled. These findings highlight personal factors associated with increases in environmental concerns that may provide viable pathways to promoting sustainable behavior at the individual and societal levels.

#### Author roles

Christopher J. Hopwood: Conceptualization, writing original draft, writing review and editing, supervision, project administration.

Ted Scwhaba: Conceptualization, data curation, formal analysis

Wiebke Bleidorn: Conceptualization, supervision

#### Acknowledgements

The authors thank the German Institute for Economic Research for making the data available for this project. We have no funding sources or conflicts of interest to report.

#### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jenvp.2021.101684>.

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